EXHIBIT 19

Vehicle Accident Analysis and Reconstruction Methods, Second Edition

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and
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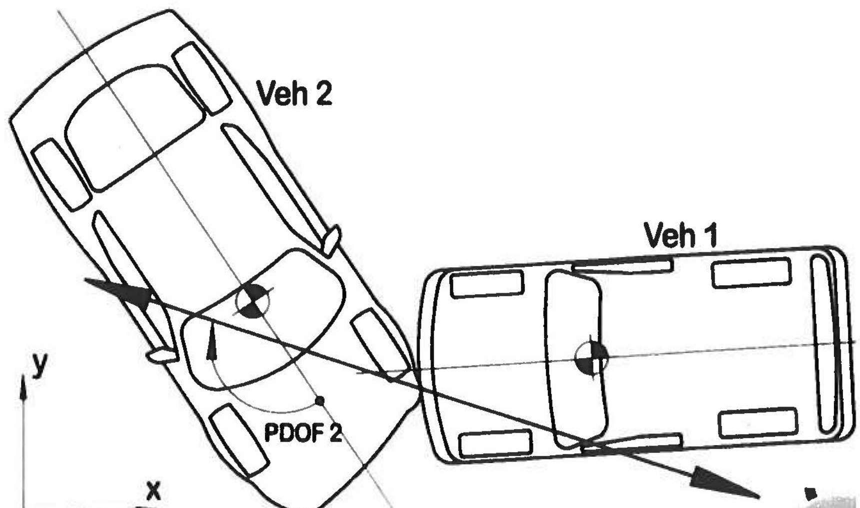

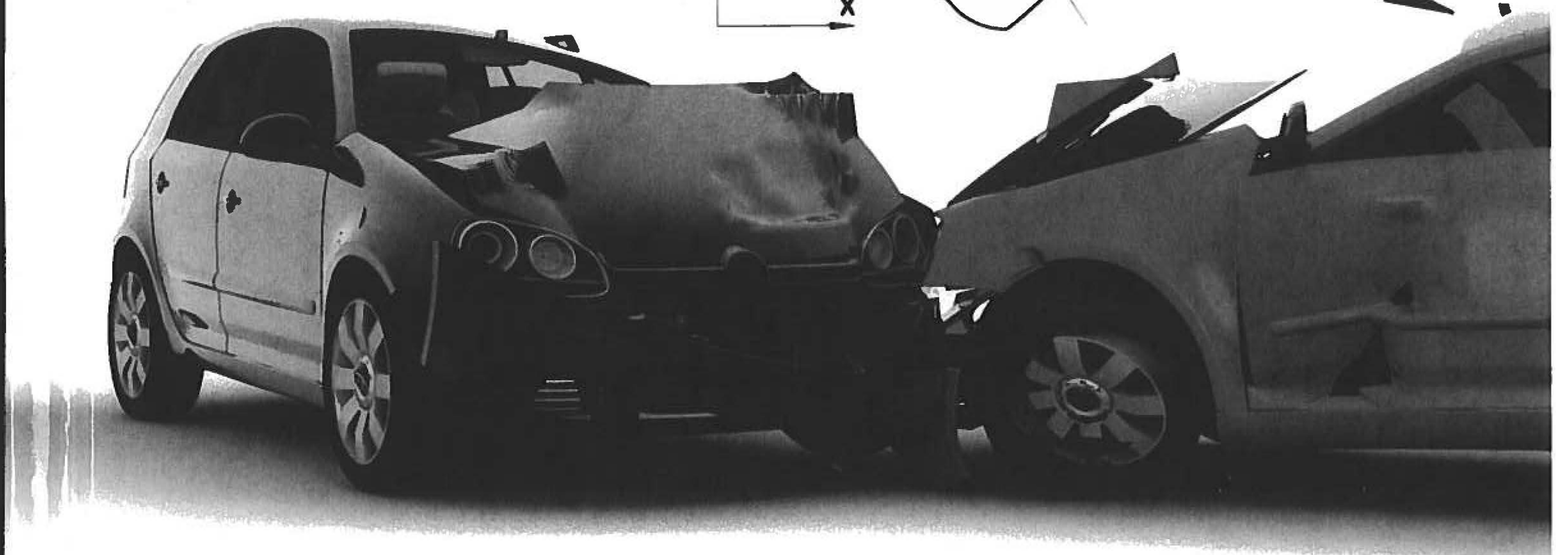

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the subject, many of which are listed in a bibliography at the end of the references to Chapter 13.

13.2 Planar Vehicle Dynamics Simulation

When carrying out an accident reconstruction, it is often useful to determine the motion of a vehicle under various conditions and combinations of acceleration, braking, and steering. For example, it may be desirable to determine what steering input at the front wheels of an automobile is necessary to complete a lane-change maneuver in 4 s at 97 km/h (60 mph) and to find out what frictional forces are developed between the tires and pavement during the maneuver. Such information can be obtained experimentally by carrying out the maneuver with an instrumented vehicle. The information can also be obtained using a vehicle dynamic simulation. Such simulation software exists with a wide range of capabilities. Some are three-dimensional such as Highway Vehicle Obstacle Simulation Model, HVOSM [13.1, 13.2], and Engineering Dynamics Vehicle Simulation Model, EDVSM [13.3], for vehicles and vehicle-barrier interactions. Some, such as Simulation Model for Automobile Collisions, SMAC [13.4, 13.5], not only simulate vehicle motion but model collision deformation as well. Some vehicle simulation software programs, such as Vehicle Dynamics Analysis Nonlinear, VDANL [13.6], and Vehicle Dynamics Models for Roadway Analysis and Design, VDM RoAD (University of Michigan Transportation Research Institute) [13.6], include a vehicle suspension system model. Others, such as VdynVB [13.7] and EDSVS [13.8], use a rigid suspension. VdynVB and EDVTS [13.8] include a semitrailer model. Driving simulators need an underlying vehicle dynamics simulation [13.9]. More sophisticated models that include simulation of crash deformation continue to be developed [13.10]. A simulation program that incorporates planar impact mechanics for complete reconstructions is PC-Crash [13.11]. Another, an accumulation of reconstruction spreadsheets with a vehicle dynamics simulation, is VCRware [13.12].

One of the most important parts of accurately modeling vehicle motion over a road is the tire model. In the large majority of applications, the most important forces that control vehicle motion are generated by the tires. In some cases, aerodynamic forces can be significant, but these are not discussed here. Tire forces used in the simulations to follow are covered in Chapter 2 and are discussed only briefly here. There are two important aspects to tire models. The first is the individual characteristics of the tire's traction (longitudinal) force and the lateral (transverse, cornering, and steering) force. The second is the way in which these characteristics are combined for simultaneous braking and steering. One effective tire model for traction and cornering forces is attributed to Fiala [13.13]. Another model for traction and cornering forces, presented by Allen, et al. [13.14], is used for both on-road and off-road applications. The model used here is a combination of the BNP tire characteristics [13.15] and the Modified Nicolas-Comstock model [13.16], both covered in Chapter 2.

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